

**Taxonomic and biological revisions
of *Calaphidius* Mackauer and the
Palearctic *Ephedrus* Haliday (Hym:
Braconidae, Aphidiinae)**

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List of papers

Re-description, distribution and host range of *Calaphidius*

Mackauer (Hymenoptera: Braconidae, Aphidiinae). - Ent.

scand. 14:77-80.

Taxonomic and biological revision of Palearctic *Ephedrus*

Haliday (Hymenoptera: Braconidae, Aphidiinae). - Ent. scand.

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Abstract

The taxonomy and biology of the two genera *Calaphidius* Mackauer and *Ephedrus* Haliday (Hymenoptera: Braconidae, Aphidiinae) were revised. *Calaphidius elegans* Mackauer was re-described and illustrated and shown to be senior synonym to *Monoctonus watanabei* Takada. The natural host of *C. elegans* is *Hamamelistes betulinus* (Horvath) (Homoptera: Hormaphididae) on *Betula* spp. At least two hyperparasitoids - *Dendrocercus paradoxus* Dessart & Gärdenfors and *Aphidencyrthus fuscipes* Dalman - seem to be restricted to *Calaphidius* in *Hamamelistes*.

The genus *Ephedrus* was divided into three subgenera: *Breviephedrus* Gärdenfors, *Lysephedrus* Stary and *Ephedrus* Haliday. The latter was subdivided into three species groups. Twenty-six species were recognized of which 18 are Palearctic. Four species were described as new and four synonymies were given. The Palearctic species were thoroughly described; keys and diagnoses were provided and the biologies and distributions were reviewed. Male morphology was shown to possess good species distinguishing characters.

A cladistic analysis revealed a rough outline of the evolutionary branches of the Aphidiinae and the relative position of *Ephedrus*. Trioxini was shown to be more related to Ephedrini than to Aphidiini. A cladistic analysis of the relationship of subgenera and species groups within *Ephedrus* was also presented. The terminology for the various morphological structures, particularly wing venation and

female and male terminalia, were discussed. The existence of allometric variation and morphological adaptations to life history characteristics were emphasized. The actual host range of a parasitoid with particular references to *Ephedrus* were found to be restricted by three categories of factors: 1) environment considered suitable by the parasitoid for host searching, 2) potentially suitable host species and 3) ability of a parasitoid to recognize a suitable host. Co-evolution between the parasitoids, the hosts and the environment affects the range of these categories of factors. The known host ranges of Palearctic *Ephedrus* species were listed. Based on reared material sex ratios were calculated for the various species and a list of hyperparasitoids was presented.



**Taxonomic and biological
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Mackauer and the Palearctic
Ephedrus Haliday (Hymenoptera:
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INTRODUCTION

All species of the braconid subfamily Aphidiinae are aphid parasitoids. The female oviposits in a living host of suitable species and developmental stage and the larva feeds within the aphid, eventually spinning a cocoon inside (except for some *Praini* genera) the hollowed-out exoskeleton which results in a so called mummy.

In Gärdenfors (1983 and 1986) the taxonomy and biology of two aphidiine genera, *Calaphidius* Mackauer, 1961 and *Ephedrus* Haliday, 1833 were revised.

Calaphidius elegans Mackauer (1961) was originally described from a single female collected by sweeping birch in West Germany. Because no illustration was presented, there was some uncertainty about its physiognomy. No revision of the genus *Ephedrus* Haliday covering the entire Palearctic region had ever been done, and the latest regional (Europe, Japan) revisions were incomplete. Moreover, there was a need for new, more reliable distinguishing characters. No keys to males and no descriptions of their distinguishing characters had ever been presented. The biologies of certain species were confused.

SUMMARY OF THE RESULTS

An extensive amount of material of *Calaphidius elegans* Mackauer was reared from *Hamamelistes betulinus* (Horvath) (Homoptera, Hormaphididae) on *Betula pendula* Roth and the species was illustrated and re-described (Gärdenfors 1983). It was compared with Japanese *Monoctonus watanabei* Takada, 1965 and found to be conspecific. Mackauer (1968) placed *Calaphidius* in the tribus Trioxini, but as shown by Gärdenfors (1986), it is actually a member of the Aphidiini. Biologically, however, the genus seems to be rather isolated. Besides being one of the only two species known to parasitize hormaphidid aphids (Mackauer & Stary 1967), at least two of the hyperparasitoids, namely *Dendrocerus paradoxus* Dessart & Gärdenfors (Dessart & Gärdenfors 1985) and *Aphidencyrthus fuscipes* (Dalman) (det. J. Noyes), seem to be restricted to *Calaphidius* in *Hamamelistes*.

The genus *Ephedrus* has a world-wide distribution but the majority of species are Holarctic and Oriental. Gärdenfors (1986) divided the genus into three subgenera: *Breviephedrus* Gärdenfors, 1986, *Lysephedrus* Stary and *Ephedrus* Haliday. The latter was subdivided into *persicae*, *plagiator* and *lacertosus* species groups. Twenty-six species were recognized of which 18 were treated as members of the Palearctic fauna. Four species - *E. chaitophori*, *E. vaccinii*, *E. longistigmus* and *E. himalayensis* - were described as new. Four new synonymies were given: *E. lacertosus* ab. *homostigma* Fahringer is a junior synonym of *E. plagiator* (Nees); *E. salicicola* Takada is a junior

synonym of *E. helleni* Mackauer; *Aphidius brevicornis* Nees and *E. plagiator* var. *minor* Stelfox are synonyms of *E. laevicollis* Thomson. Lectotypes of *E. lacertosus* ab. *homostigma* Fahringer and *Aphidius laevicollis* Thomson were designated. The Palearctic species were thoroughly described - females as well as males; keys and diagnoses were provided and the biologies and distributions were reviewed. Male morphology - hitherto almost completely disregarded - was shown to possess good species distinguishing characters; in some species the males are even easier to identify than females.

A cladistic analysis of the main aphidiine groups, utilizing several new characters, revealed that the sister-group of *Ephedrus* probably is *Parephedrus* + *Toxares* + *Pseudephedrus* + *Vanhartenia* + *Trioxini*. In contrast to the classification of Mackauer (1968), where the *Trioxini* was placed together with the *Aphidiini* (and *Aclitini*) in the subfamily *Aphidiinae* (within *Aphidiidae*), this analysis showed that *Trioxini* and *Aphidiini* belong to distinctly different evolutionary branches of the *Aphidiinae* (cf. Fig. 2:1 in Gärdenfors 1986). The relative position of the *Praini* was not settled in the analysis. The biology, however, indicates that *Praini* may belong to the *Ephedrus* - *Trioxini* branch.

The terminology adopted for identical morphological structures has been astonishingly diverse within the various hymenopterous groups as well as within the *Aphidiinae*. In Gärdenfors (1986) the terminology for the various structures, particularly wing venation and female and male terminalia, were discussed and certain terms, judged to be

the most reasonable and widely used ones were proposed for future use. For instance, the Ross-Comstock-Needham system for wing venation was advocated.

Gärdenfors (1986) emphasized that considerable intraspecific morphological variation exists correlated to body size, i.e. there is a noticeable allometric variation. Thus compared with smaller specimens large individuals have longer flagellar segments with more numerous rhinariae, temples that are constricted behind the eyes, prominent notauli, propodeum and first metasomal tergite (MT1) with a rugged surface, more slender ovipositor sheaths, longer legs, generally more numerous hairs, and brighter coloration. This allometric variation also, to some degree, applies at the interspecific level. Thus a large species generally has longer flagellar segments, more constricted temples, more slender ovipositor sheaths, etc, than a smaller species.

At the species level, there are morphological adaptations to life history characteristics. Thus *E. validus*, the females of which parasitize waxy, subterranean aphids, has a rugged and densely pubescent body surface. These features probably help her to stay clean during and after her underground forays. Similar adaptations occur in other species (e.g. *Paralipsis enervis* (Nees) and *Aeropraon lepelleyi* (Waterstone)) which parasitize subterranean or waxy aphids. The shape of a parasitoid species' MT1 seems to, at least to some degree, reflect the morphology (e.g. length of the aphid leg) and behaviour (e.g. leaf-curling vs. the ability to rapidly escape) of their major host species.

The actual host ranges of the *Ephedrus* species are restricted by several factors that can be grouped into three categories (cf. Fig. 10 in Gärdenfors 1986): 1) the environment considered suitable by the parasitoid for host searching, 2) the potentially suitable host species and 3) the ability of a parasitoid to recognize a suitable host. Only those aphid species meeting all three conditions will serve as targets for the parasitoids in nature. Co-evolution between the parasitoids, the aphids and the environment (including other organisms in the ecosystem) affects the range encompassed by these three categories of factors and their degree of overlap, thereby affecting the actual host-range of the parasitoid. For instance, the parasitoid "tries" (through natural selection) to overcome the chemical and immunological defences of certain aphids, thus extending the circle (=number) of potentially suitable host species, whilst the aphid "tries" to escape parasitoids (and predators) e.g. by producing toxins or shifting environment. The degree of the overlap of the three circles (Fig. 10 in Gärdenfors 1986) varies geographically. Thus the host range of a widely distributed parasitoid species differs in different parts of its geographical range. This is important to bear in mind when importing parasitoids from remote areas for biological control.

Gärdenfors (1986) listed the known host-range for the various *Ephedrus* species. However, the literature contains many errors regarding hosts of parasitoids: due to insufficient knowledge or carelessness, the parasitoids or the hosts have often been misidentified. One common source of error arises from the frequent habit of aphids to leave

their colony after being parasitized. Thus, it is very common to find the mummy of an aphid species on some herb, although the aphid actually lives on a nearby tree. If the mummy is not examined carefully, it can be easily concluded that it is a species which normally lives on this herb. It is wise to always retain the mummies along with the reared specimens, enabling future re-examination.

Many aphidiine species show a sex ratio that is more or less female biased. Judging from a rather small amount of reared material it seems as though the more primitive *Ephedrus* species have a female-biased sex ratio while the majority of the more advanced species have an 50-50 ratio.

The aphidiines are attacked by several hymenopterous hyperparasitoid groups (Gårdenfors 1984). The following species have emerged from *Ephedrus* mummies collected in Sweden and Greece: *Dendrocerus carpenteri* (Curtis) (Megaspilidae); *Asaphes vulgaris* Walker, *A. suspensus* (Nees), *A. petiolatus* (Zetterstedt), *A. sp.*, *Pachyneuron formosum* Walker, *P. sp.*, *Coruna clavata* Walker (Pteromalidae); *Alloxysta victrix* (Westerm.), *A. sp.* and *Phaenoglyphis villosa* (Hartig) (Cynipidae, Alloxystinae).

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